Missouri Department of Natural Resources

Biological Assessment and Fine Sediment Study

Upper Big River
Washington County

2001-2002

Prepared for:

Missouri Department of Natural Resources
Water Protection and Soil Conservation Division
Water Pollution Control Program

Prepared by:

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1.0 Introduction

At the request of the Missouri Department of Natural Resources (**MDNR**) Water Pollution Control Program (**WPCP**), the Environmental Services Program (**ESP**) Water Quality Monitoring Section (**WQMS**) conducted a macroinvertebrate bioassessment and fine sediment study of the upper Big River in Washington County.

The upper Big River study area, downstream of Belgrade and upstream of Irondale, Missouri, is considered in the 10 CSR 20-7 Rules of Department of Natural Resources, Clean Water Commission, Water Quality Standards as a class "P" stream. A class P stream maintains permanent flow even in drought periods. Beneficial use designations are "Livestock and Wildlife Watering (**LWW**) and Protection of Warm Water Aquatic Life and Human Health-Fish Consumption (**AQL**)".

1.1 Justification

The lower Big River is 303(d) listed for lead and sediment possibly due to runoff from the lead mine tailings piles near the river. The upper reaches of Big River have few known mines that may influence the river's community, however, one abandoned barium strip mine is located near Furnace Creek, which enters Big River near Missouri Highway 21.

In 1975, a barite tailings impoundment dam on Big River failed causing an extensive fish-kill and impairment of macroinvertebrate communities mainly due to fine sediment input (Duchrow 1976; Meneau 1997). Fine sediment particles (ca. <2.0 mm) may homogenize and embed substrates when washed into streams, making it unsuitable for macroinvertebrate communities (Zweig 2000). Abandoned impoundment ponds may emit fine sediment and unsuspectingly impact the aquatic communities.

The metals composition (i.e. character) of the sediment may influence macroinvertebrate communities as well. Clements (1991) found a lowered percent composition or elimination of Ephemeroptera and increased abundance of Chironomidae, especially Orthocladiinae, and Hydropsychidae (net-spinning caddisflies), downstream from metals impacts in the absence of organic pollution. The replacement of intolerant taxa by tolerant taxa suggests that the health of the aquatic community was affected at a basic level. Besser et al. (1987) said aquatic organisms in tributaries of Big River located downstream from tailings piles contained concentrations of lead, cadmium, and other heavy metals.

The character of fine sediment may also reveal its source. Kramer (1976) and Jenett et al. (1981) reported elevated levels of lead and zinc in Flat River, St. Francois County. Concentrations of lead and zinc were elevated within algae, crayfish, and minnows from lower Flat River. They believed the sources were brought to Flat River via tributaries that drained Elvins and Federal tailings piles. In 2001, the MDNR, ESP, Water Quality Monitoring Section identified Elvins Tailings Pile as a potential source of lead and zinc laden sediment that was found in Flat River.

The zinc appeared to diffuse into the water column in concentrations above MDNR (2000) Water Quality Standards (Humphrey and Lister 2002).

The potential for abandoned mines to discreetly impair aquatic communities and the suspected conditions downstream on Big River raise the question of upstream influences. It was our intention to determine if the abandoned barium strip mine near Furnace Creek was impairing Big River. A bioassessment and sediment study was conducted and scores were compared upstream to downstream of the potential influence and with biological reference streams within the Ozark/Meramec Ecological Drainage Unit (**EDU**).

In 2001, a study plan for a bioassessment and fine sediment study was submitted to the MDNR, WPCP (Appendix A). The WQMS was responsible for the proposed bioassessment and fine sediment study on Big River, Washington County.

1.2 Purpose

The purpose of the study was to determine if Big River was impaired by runoff from an abandoned barium strip mine on Furnace Creek.

1.3 Objectives

1) Determine if the macroinvertebrate community and water quality were affected by mining influences.

2) Determine if fine sediment and heavy metals were present in Big River and determine their origin.

3) Define habitat influences on Big River.

1.4 Tasks

1) Conduct a bioassessment of the macroinvertebrate community of Big River, Washington County.

2) Conduct a fine sediment assessment and character study on Big River.

3) Conduct a habitat assessment on Big River.

1.5 Null Hypotheses

The macroinvertebrate communities within the control and test stations of the upper Big River, Washington County are similar.

The macroinvertebrate communities of the test stations and biological criteria reference streams for the Ozark/Meramec EDU are similar.

Water quality is similar between control and test stations.

There is no significant difference in the percentage and character of the fine sediment between upstream controls and downstream test stations.

Habitat assessments are similar between control and test stations.

2.0 Methods

This project was conducted by the Water Quality Monitoring Section of the Missouri Department of Natural Resources, Air and Land Protection Division, Environmental Services Program. Kenneth B. Lister, Steve Humphrey, and the staff of the Water Quality Monitoring Section conducted the study.

2.1 Study Timing

Sampling was conducted during the summer, fall, and spring. A physicochemical water analysis was conducted for the July 11, 2001 reconnaissance. The sample period for the first complete bioassessment included September 20, October 10, and October 11, 2001. Fine sediment percentage estimation and collection of sediments for characterization occurred on September 26-27, 2002. The second complete bioassessment date was April 4, 2002.

2.2 Station Descriptions

Stations were positioned to provide for a control upstream from all known mining influences and two test stations downstream from the abandoned strip mine near Furnace Creek (Table 1, Figure 1). Station #3 was the upstream control station, while #2 and #1 were the downstream test stations. Stations throughout this project are listed from upstream to downstream (e.g. #3, #2, and #1). Furnace Creek was sampled for water quality only.

Table 1
Station Number, Legal, and Descriptive Information for Big River

Station Number	County	Location ¼, Section, Township, Range	Description
#3	Washington	SE sec. 26, T. 36 N., R. 02 E.	Upstream Control- Upstream of Furnace Creek confluence
Furnace Creek	Washington	SW sec. 24, T. 36 N., R. 02 E.	Potential barium mine influence; Water Quality only
#2	Washington	S½ sec. 24, T. 36 N., R. 02 E.	Test Station- Downstream from Furnace Creek confluence
#1	Washington	NE sec. 29, T. 36 N., R. 03 E.	Test Station- Downstream from all; Up and downstream Cedar Creek confluence

2.2.1 Ecological Drainage Unit

An EDU is a region in which biological communities and habitat conditions can be expected to be similar. Table 2 compares the land cover percentages from the Ozark/Meramec EDU and the 14-digit Hydrologic Unit (**HU**), #07140104010003, which contains the Big River study reach. Percent land cover data were derived from Thematic Mapper (TM) satellite data collected between 1991 and 1993 and interpreted by the Missouri Resource Assessment Partnership (MoRAP). Big River appears to be similar in percent land cover and can be compared with biological reference streams of the EDU for habitat assessments, biological assessments, and fine sediment estimation/characterizations.

Table 2
Percent Land Cover. Percentages based on 14-Digit Hydrologic Unit Codes
for the Ozark/ Meramec EDU and Big River.

Land Cover (%)	Urban	Crops	Grassland	Forest	Swamp/Marsh
Ozark/ Meramec EDU	1.3	1.7	28.5	67.1	0
Big River, Washington County	0	0.4	22.4	75.7	0

2.3 Habitat Assessment
A standardized assessment procedure was followed as described for Riffle/Pool Habitat in the Stream Habitat Assessment Project Procedure (**SHAPP**). The habitat assessment was conducted on the three upper Big River stations in October 2001 and comparisons were made between scores from upstream to downstream. Habitat scores for Big River stations were also compared to four of the six stations in ESP's Biological Criteria for Perennial/ Wadeable Streams database. These four stations were chosen for references in the habitat assessment comparisons because they were: 1) biological reference streams in the EDU and 2) assessed in October 2001, which was approximately the same time as Big River habitat assessments.

2.4 Biological Assessment
Biological assessments consist of macroinvertebrate community and physicochemical water analyses. Complete bioassessments were conducted twice at three stations on Big River in two seasons.

2.4.1 Macroinvertebrate Collection and Analyses
A standardized macroinvertebrate sample collection and analysis procedure was followed as described in ESP's Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (**SMSBPP**). Three standard habitats (e.g. flowing water over coarse substrates, depositional substrates in non-flowing water, and root-mat) were sampled at all locations. Macroinvertebrate data from Big River were compared using the ESP's Biological Criteria for Perennial/ Wadeable Streams. Macroinvertebrates were collected October 10-11, 2001 and April 4, 2002.

Macroinvertebrate data were analyzed using two methods. The first analyses used the SMSBPP method to perform both a longitudinal evaluation and a comparison of all stations versus biological criteria. Four metrics are used in the SMSBPP evaluation: 1) Total Taxa (**TT**), 2) Ephemeroptera/Plecoptera/Trichoptera Taxa (**EPTT**), 3) Biotic Index (**BI**), and 4) Shannon Diversity Index (**SDI**). The second analyses was an evaluation of the dominant macroinvertebrate families (**DMF**) using percent composition of predominant macroinvertebrate taxa and fine sediment or heavy metals tolerances of macroinvertebrate taxa present.

2.4.2 Physicochemical Water Collection and Analyses
Physicochemical water samples were collected according to MDNR, ESP, Standard Operating Procedures (**SOPs**) and Project Procedures (**PPs**) for sampling and analyzing physical and chemical samples. Results are reported for physicochemical water variables in chronological order. Tests varied slightly from the initial visit in July 2001, to the main sample collections taken in September 2001 and April 2002.

July 2001 physicochemical variables collected were pH, temperature (C^0), conductivity (uS/cm), hardness (CaCO3), total recoverable barium, calcium, cadmium, magnesium, lead, and zinc. Metals results are reported as total recoverable (ug/L). Temperature, pH, and conductivity were conducted in the field, while composite samples were analyzed by the ESP laboratory.

September 2001 and April 2002 samples were more comprehensive. Physicochemical variables collected were pH, temperature (C^0), conductivity (uS/cm), dissolved oxygen, discharge, turbidity, hardness (CaCO3), ammonia-nitrogen, nitrate/nitrite-nitrogen, Total Kjeldahl Nitrogen (**TKN**), sulfate (September only), chloride (September only), total phosphorus, and dissolved barium, calcium, cadmium, copper, iron, magnesium, lead, and zinc. These were collected at the three stations on upper Big River. Samples were collected per MDNR-FSS-001 Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations. Samples were analyzed as before, either in the field or at the ESP laboratory.

All samples were kept on ice until they were delivered to the ESP laboratory. The WQMS measured turbidity in the WQMS Biology Laboratory. All other samples were delivered to the ESP Chemical Analysis Section (**CAS**) in Jefferson City, Missouri for analyses.

Physicochemical comparisons were made between the upstream (i.e. control) and two downstream (i.e. test) stations. Results were also compared with acceptable limits according to the Missouri Water Quality Standards (MDNR 2000).

Acceptable limits for Water Quality Standards (MDNR 2000) are dependent on a stream's classification. Beneficial use designations for Big River are "Livestock and Wildlife Watering (**LWW**), Protection of Warm Water Aquatic Life, and Human Health-Fish Consumption (**AQL**)". Big River is classified for the "Protection of Aquatic Life" or a "General Warm-Water Fishery" (**GWWF**). Furthermore, acceptable limits are dependent on the rate of exposure. These toxicity limits are based on the lethality of a toxicant given long (i.e. chronic toxicity, **c**) or short-term exposure (i.e. acute toxicity). Hardness concentrations were necessary to further determine acceptable limits based on the solubility of heavy metals.

2.4.3 Discharge

Stream flow was measured using a Marsh-McBirney Flow Meter at each station. Measurements were taken and discharge was interpreted as cubic feet per second (**cfs**). Methodology was in accordance with SOP, MDNR-WQMS-113 Flow Measurement in Open Channels.

2.5 Fine Sediment

In-stream deposits of fine sediment (i.e. particle size ca. <2 mm) were estimated for percent coverage per area and characterized for composition of total recoverable metals (**TR**, ug/kg). This was done once in September 2001.

2.5.1 Fine Sediment Percentage and Characterization

The relative percentage of fine sediment (<2.0 mm) was estimated and characterized for each station. Each sampling station contained three sediment estimation areas (i.e. **grids**). In order to ensure sampling method uniformity, grids were located at the upper margins of pools and lower margins of riffle/run habitats. Depths of the sample areas did not exceed two (2.0) feet and water velocity was less than 0.5 feet per second (fps). A Marsh McBirney flow meter was used to ensure that water velocity of the sample area was within this range.

The percentage of fine sediment was estimated at each station by constructing a virtual grid of potential quadrats (Figure 2). A tape measure was anchored from bank to bank that comprised the downstream edge of each grid. Each grid consisted of six contiguous transects that traversed the stream. One sample quadrat (ca. 10” x 10”) was randomly placed directly on the substrate within each of the six transects. Placement of the quadrat within each transect was determined by using a random number that equated to one foot increments from one bank. The trailing edge of the quadrat was placed on the downstream transect edge. Two investigators estimated the percentage of the stream bottom that consisted of fine sediment sized particles within each quadrat. The estimates were accepted if the two observations were within a ten percent margin of error. If estimates diverged more than ten percent, the investigators repeated the process until the estimates were within the acceptable margin of error. An average of these two estimates was recorded and used for analyses.

Fine sediment was characterized by determining its content of total recoverable lead and zinc (ug/kg). One composite sample of the fine sediment was collected at each grid, which equated to three samples per station. Each composite consisted of three (3) two-ounce samples of fine sediment sized particles that was dredged from the substrate and placed into an eight ounce jar. Dredging did not exceed a depth of two inches. The lid of the two-ounce jar was used to retain the fine sediment while retrieving the sample through the water column. If fine sediment was not found in sufficient quantities within the grid, a representative composite collection was taken from an area near the study grid. Samples were kept on ice and delivered to the ESP CAS in Jefferson City, Missouri for analyses.

2.5.2 Fine Sediment Data Analyses

Statistical analyses of the relative percentage of fine sediment found in the substrate were conducted using Sigmastat Version 2.0 (1997). Kruskal-Wallis Oneway Analysis of Variance on ranks (ANOVA on ranks) illustrated differences between sample stations. If significant differences ($p<0.05$) were detected between stations, an All Pairwise Multiple Comparison

Procedure Tukey Test was conducted to identify where differences ($p<0.05$) were found. Each station's data (n=18 quadrats) were included in the comparison between stations. Fifty-four observations were made for the three stations on the upper Big River segment.

Statistical analyses for metals content between stations were also conducted using Kruskal-Wallis ANOVA on ranks. Since each station consisted of three composite samples, each stations' data (n=9) were used in the analysis. Significant differences ($P<0.05$) were identified as before.

Kruskal-Wallis ANOVA and Dunn's test were used to determine the location and extent of influence of Cedar Creek on Station #1. The data from the one grid that was located below the Cedar Creek confluence were removed to illustrate Cedar Creek's influence on Big River. Dunn's Rank Comparison was used to identify differences between stations with missing data.

2.6 Quality Control

Quality control was used as stated in the MDNR Standard Operating Procedures and Project Procedures.

3.0 Results and Analyses

Variables included in the results were found to have high values or interesting trends. Habitat assessments, biological assessments, which include a macroinvertebrate assessment and physicochemical water analyses, fine sediment coverage estimation, and fine sediment characterization are part of this results section.

3.1 Habitat Assessment

According to the <u>Stream Habitat Assessment Project Procedure</u> (**SHAPP**), a study stream that scores greater than 75 percent of reference stream conditions is considered to have habitat that supports a similar biological community.

Two comparisons were made to adequately assess the quality of habitat on Big River. The first comparison was of the habitat scores from upstream to downstream stations. Secondly, the Big River station scores were compared to the highest and mean habitat scores from four of the six BIOREF stations assessed for habitat quality in October 2001 in order to determine the percentage of similarity.

Habitat assessment scores for the three Big River stations were relatively similar from upstream to downstream (Table 3). Big River Station #3 served as the upstream control with a score of 135. Station #2 was assessed a score of 127, and #1 was 123. Station #2 was 94 percent of the upstream control, while Station #1 was 91 percent of the upstream Station #3. Stations on Big River appeared to be similar to each other.

Big River stations were then compared to the four BIOREF stations using two methods (Table 3). The first was a comparison of upper Big River stations with the highest scoring BIOREF station (i.e. Meramec River #2). All upper Big River stations exceeded 75 percent of the highest reference station. The second comparison was between Big River stations and the mean of the four BIOREF stations (i.e. mean BIOREF). The upper Big River mean percentages were approximately five percent higher than the highest reference comparison and all were at least 80 percent of the mean of the four BIOREF stations. All stations were considered fully capable of sustaining aquatic communities.

Table 3
Habitat Assessment Scores (SHAPP) for Big River and
Biological Criteria Reference (BIOREF) Stations, October 2001

Stations	Big River #3	Big River #2	Big River #1	Meramec River #2 (BIOREF)	Meramec River #1 (BIOREF)	Huzzah Creek #2 (BIOREF)	Huzzah Creek #1 (BIOREF)	Mean BIOREF
Habitat Score	135	127	123	162	146	145	157	153
Percent of Highest BIOREF Score	83	78	76	100	90	90	97	94
Percent of Mean BIOREF	88	83	80	106	95	95	103	100

3.2 Biological Assessment

As outlined in the methods, macroinvertebrate data were evaluated by two methods. The first analysis was metric evaluation per the Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (**SMSBPP**). The second analysis of the biological data was an evaluation of dominant macroinvertebrate family (**DMF**) composition.

3.2.1 Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (SMSBPP)

The SMSBPP metric evaluations using numeric biocriteria were calculated for each station using streams of the Ozark/Meramec EDU in the biocriteria reference database. A maximum score of five (5) is possible for each of the four metrics (i.e. Total Taxa TT; EPT Taxa EPTT; Biotic Index, BI; Shannon Diversity Index, SDI). On a scale of twenty (20), 16-20 is considered full biological sustainability, 10-14 is partial biological sustainability, and 4-8 is non-biological sustainability. These criteria were calculated for the October and April sampling seasons.

During the October 2001 sample season, Stations #3, #2, and #1 were considered to have full sustainability according to the requirements of the SMSBPP total scores (Table 4). The total score trend decreased from upstream to downstream with scores of 20, 18, and 16, respectively. The total taxa dropped from 83 at Station #2 to 74 at Station #1, and a moderate drop in the Shannon Diversity Index from 3.30 to 2.52 accounted for the decreased combined score at Station #1.

Table 4
Metrics Scores and Sustainability for Upper Big River and
Biological Criteria Database (BIOREF) Stations (in gray), n=7 stations, October 2001

Upper Big River	3	2	1	Score 5	Score 3	Score 1
Sample No.	0137077	0137076	0137078	--	--	--
Total Taxa	84	83	74	>78	78 – 39	<39
EPT Taxa	23	20	23	>21	21 - 10	<10
Biotic Index	5.06	5.20	5.05	<5.78	5.78 - 7.89	>7.89
Shannon DI	3.35	3.30	2.52	>3.09	3.09 - 1.54	<1.54
Total Score	20	18	16	20-16	14 - 10	8-4
Sustainability	Full	Full	Full	Full	Partial	Non

In April 2002, Stations #3, #2, and #1 were again considered to have full sustainability according to the requirements of the SMSBPP (Table 5). Total scores appeared to follow a similar trend of decreasing from upstream to downstream stations. However, Station #2 was slightly lower (i.e. 16) than Station #1 (i.e. 18), unlike the trend of the previous season. The total taxa value of 92 and EPT taxa of 27 at Station #2 accounted for the drop in score from the control station (i.e. 20).

Table 5
Metrics Scores and Sustainability for Upper Big River and
Biological Criteria Database (BIOREF) Stations (in gray), n=6 stations, April 2002

Upper Big River	3	2	1	Score 5	Score 3	Score 1
Sample No.	0218023	0218024	0218025	--	--	--
Total Taxa	102	92	104	>92	92 - 46	<46
EPT Taxa	31	27	29	>29	29 - 14	<14
Biotic Index	5.38	5.52	5.75	<5.79	5.79 - 7.90	>7.90
Shannon DI	3.63	3.53	3.38	>3.33	3.33 - 1.66	<1.66
Total Score	20	16	18	20 – 16	14 - 10	8 – 4
Sustainability	Full	Full	Full	Full	Partial	Non

3.2.2 Dominant Macroinvertebrate Families

The number of macroinvertebrate Total Taxa, EPT taxa, and percent EPT for October 2001 and April 2002 Big River stations are presented in Tables 6 and 7, respectively. These tables also provide, in bold type, the percent composition for the five dominant macroinvertebrate families (**DMF**) at each station. For comparison among stations, percentages in plain type represent macroinvertebrate families that were dominant at either of the two other Big River stations during the same sampling period or taxa of particular interest.

October 2001 macroinvertebrate samples from Big River contained 84 total taxa at the control Station #3, while test Stations #2 and #1 were found to contain 83 and 74 total taxa, respectively (Table 6). EPT taxa ranged from 20 to 23 among the three stations.

Ephemeroptera (mayflies) comprised most of the EPT taxa and abundance. They made up approximately 40 percent of the sample at #3, 46 percent at #2, and 75 percent at #1 (Table 6). Plecoptera (stoneflies) and Trichoptera (caddisflies) made up a small number of taxa and low numbers of organisms in the October macroinvertebrate samples. Stoneflies accounted for only one rarely collected taxon at Big River Stations #3 and #2, and these organisms were not collected at Big River #1. Caddisflies comprised 7, 6, and 10 taxa at Big River Stations #3, #2, and #1, respectively (Appendix B). Percent occurrence was less than four percent at each station.

The dominant macroinvertebrate families were similar among the three Big River stations in October 2001 (Table 6). Heptageniidae (flat-headed mayflies) were one of the five most abundant families at each Big River station. Average abundance was 20 percent at Big River #3, 12 percent at Big River #2, and 16 percent at Big River #1. Elmidae (elmid beetles), Chironomidae (midge flies), Psephenidae (water penny beetles), Isonychiidae (brush-legged mayflies), and tricorythid mayflies made up nearly all of the remaining dominant families at each Big River station. Hyalellidae (amphipods) were a dominant family at Big River #3 due to a large number of this taxon collected from root-mat habitat at this station.

Table 6
Upper Big River Macroinvertebrate Composition and Dominant Macroinvertebrate Families (DMF) per Station, October 2001

Variable-Station	3	2	1
Sample Number	01-37077	01-37076	01-37078
Total Taxa	84	83	74
Number EPT Taxa	23	20	23
% Ephemeroptera	39.7	46.2	75.1
% Plecoptera	0.1	0.2	0.0
% Trichoptera	3.4	1.8	1.4
% Dominant Macroinvertebrate Families (DMF; below)			
Heptageniidae	**20.0**	**12.0**	**16.3**
Hyalellidae	**15.0**	3.8	0.3
Elmidae	**14.6**	**9.2**	6.7
Chironomidae	**12.7**	**12.1**	**8.2**
Psephenidae	**7.8**	3.4	0.8
Tricorythidae	1.8	**16.2**	**39.5**
Isonychiidae	7.6	**8.8**	**9.3**
Caenidae	4.2	7.4	**9.4**

Big River macroinvertebrate samples contained a large number of total taxa and EPT taxa in April 2002 (Table 7). The number of total taxa was 102, 92, and 104 at Big River #3, #2, and #1, respectively. The number of EPT taxa at these stations was 31 at Big River #3, 27 at Big River #2, and 29 at Big River #1.

Mayflies accounted for most of the EPT taxa and averaged about 15 taxa per station (Table 7). Several stonefly and caddisfly taxa were present, but were not abundant at any station. Stoneflies averaged six taxa per station and caddisflies accounted for an average of about seven taxa per station (Appendix B).

April 2002 dominant macroinvertebrate families were similar among the Big River stations (Table 7). Chironomidae was the dominant family and made up a maximum of 37 percent of the benthos at Big River #2. Chironomidae are often the dominant family in Ozark streams in the spring and, unless they make up the majority of the abundance, usually do not indicate impairment. Heptageniidae, Caenidae, Baetidae (small minnow mayflies), and Elmidae were the remaining dominant four macroinvertebrate families at each of the Big River stations. Caenidae was most abundant (e.g. 19 percent) at Big River #1.

Table 7
Upper Big River Macroinvertebrate Composition and
Dominant Macroinvertebrate Families (DMF) per Station, April 2002

Variable-Station	3	2	1
Sample Number	02-18023	02-18024	02-18025
Total Taxa	102	92	104
Number EPT Taxa	31	27	29
% Ephemeroptera	37.4	31.5	44.2
% Plecoptera	3.8	2.0	1.2
% Trichoptera	2.5	2.7	1.3
% Dominant Macroinvertebrate Families (DMF; below)			
Chironomidae	**28.3**	**37.2**	**26.2**
Heptageniidae	**13.3**	**9.8**	**6.8**
Caenidae	**10.0**	**8.1**	**19.2**
Baetidae	**6.8**	**7.0**	**11.1**
Elmidae	**5.4**	**10.6**	**12.0**
Ephemerellidae	3.7	2.4	2.1

3.2.3 Physicochemical Water

Results were arranged in chronological order by groups for the three seasons' physicochemical water sample analyses. Comparisons were made between upstream and downstream on the upper Big River and with Water Quality Standards (MDNR 2000), if necessary or applicable.

Physicochemical water samples were collected and analyzed in July 2001. Total recoverable metals were collected but not comparable to Water Quality Standards (MDNR 2000) (Table 8). Total recoverable metals did not seem excessive and would not have exceeded the Water Quality Standards (MDNR 2000) had they been the dissolved metals fraction. However, a trend was apparent from upstream to downstream. Total recoverable barium (ug/L) concentrations increased by more than three-fold from the upstream reconnaissance Big River #3 station (Clear Creek) to Big River #2 station (Furnace Creek). Downstream levels from Furnace Creek were still over twice that of the Clear Creek confluence.

Table 8
Physicochemical Water Results from Reference and Test Stations for the July 2001 Reconnaissance. Units mg/L Total Recoverable (TR) unless otherwise noted.

Variable-Station	Big River #3 @ Clear Creek Reference station July 2001	Furnace Creek #2 @ Hwy 21 Test station July 2001	Big River #1 @ MDC Bootleg Access Test Station July 2001
Phys/Chem Sample Number	01-26783	01-26782	01-26781
pH (Units)	8.00	8.20	7.90
Temperature (C^0)	26	25	25
Conductivity (uS)	390	492	441
Hardness $CaCO_3$	210	280	240
Barium, TR	106	398	240
Calcium, TR	40.6	51.1	46.8
Cadmium, TR ug/L	<2.00	<2.00	<2.00
Magnesium, TR	25.5	35.8	31.0
Lead, TR ug/L	<3.4	<3.4	<3.4
Zinc, TR ug/L	<5.00	6.25	<5.00

In September 2001, all physicochemical samples were within acceptable ranges (Table 9). However, barium again appeared to follow a trend (Figure 3). Station #3 upstream of Furnace Creek contained 120 ug/L of dissolved barium. The water sample taken directly in Furnace Creek, which is downstream from the abandoned mine, showed a barium level of 392 ug/L. Immediately downstream of the Furnace Creek confluence with Big River, at Station #2, the barium concentration increased to 201 ug/L. The level of barium declined to 151 ug/L at Station #1 several miles downstream. It appears that some influence of barium was detected from the Furnace Creek basin. Despite this, Water Quality Standards show no standard level for the “Protection of Aquatic Life”. Barium levels were specified as not acceptable in public drinking water and groundwater at or above 2000 ug/L (MDNR 10CSR 20-7.031, 2000).

Table 9
Physicochemical Water Results for Reference and Test Stations in September 2001.
Units mg/L unless otherwise noted. **Bold**=outstanding value

Variable-Station	Big River #3 Upstream Reference September 2001	Furnace Creek Test Station September 2001	Big River #2 Test Station September 2001	Big River #1 Test Station September 2001
Phys/Chem Sample Number	01-39371	01-39369	01-39370	01-39368
pH (Units)	8.2	8.4	8.2	8.3
Temperature (C^0)	23	22	21	20
Conductivity (uS)	421	500	439	436
Dissolved O_2	8.0	9.2	8.9	9.0
Discharge (cfs)	4.00	--	4.70	4.20
Turbidity (NTUs)	1.67	<1.00	1.07	<1.00
Hardness $CaCO_3$	220	280	240	240
Ammonia-N	<0.05	<0.05	<0.05	<0.05
Nitrate/Nitrite-N	<0.05	0.05	0.06	<0.05
TKN	<0.20	<0.20	<0.20	<0.20
Sulfate	11.4	8.00	9.85	10.8
Chloride	<5.00	<5.00	<5.00	<5.00
Total Phosphorus	<0.05	<0.05	<0.05	<0.05
Barium, Dissolved ug/L	120	**392**	201	151
Calcium, Dissolved	43.8	53.1	46.6	45.6
Cadmium, Dissolved g/L	<1.00	<1.00	<1.00	<1.00
Copper, Dissolved ug/L	<10.0	<10.0	<10.0	<10.0
Iron, Dissolved ug/L	5.90	<5.00	5.15	<5.00
Magnesium, Dissolved	27.0	36.1	29.7	30.2
Lead, Dissolved ug/L	<2.5	<2.5	<2.5	<2.5
Zinc ug/L	<5.00	<5.00	<5.00	<5.00

April 2002 results were similar in the physicochemical variables, however, discharge was much greater (ca. 10 times) than the September sampling (Table 10). Again, barium followed a trend that was low at the control station #3 (120 ug/L), increased in Furnace Creek (316 ug/L), and declined in Big River below the confluence (Figure 3).

Interestingly, dissolved copper was found in high concentrations during sampling in April 2002 (Table 10, Figure 4). Dissolved copper at station #1 (43.2 ug/L) was above acceptable Water Quality Standards (MDNR 2000) at both the “acute” (43 ug/L) and “chronic” (28ug/L) toxicity

levels, given a hardness of <200 mg/L $CaCO_3$. Furnace Creek also contained relatively high concentrations (29.2 ug/L) of copper, second only to station #1. Furnace Creek concentrations did not exceed Water Quality Standards (chronic = 38 mg/L $CaCO_3$) because of decreased solubility given the higher hardness level (>200 mg/L $CaCO_3$; Figure 4). The control Station #3 was lowest in dissolved copper, followed by Station #2.

Table 10
Physicochemical Water Results for Reference and Test Stations in April 2002. Units mg/L unless otherwise noted. **Bold** exceeds WQS chronic **c,** acute **a,** or notable increase.
No sulfate or chloride sampled. *=Dissolved oxygen meter malfunction, missing data

Variable-Station	Big River #3 Reference Station- April 2002	Furnace Creek Test Station April 2002	Big River #2 Test Station April 2002	Big River #1 Test Station April 2002
Phys/Chem Sample Number	02-16516	02-16517	02-16518	02-16519
pH (Units)	8.6	8.3	8.3	8.4
Temperature (C^0)	9	10	13	13
Conductivity (uS)	288	449	307	316
Dissolved O_2	*	*	*	*
Discharge (cfs)	46.2	-	54.5	61.3
Turbidity (NTUs)	1.01	<1.00	<1.00	<1.00
Hardness $CaCO_3$	150	240	160	170
Ammonia-N	<0.05	<0.05	<0.05	<0.05
Nitrate/Nitrite-N	0.14	<0.05	0.16	0.15
TKN	<0.20	<0.20	<0.20	<0.20
Total Phosphorus	<0.05	<0.05	<0.05	<0.05
Barium, Dissolved ug/L	61.5	**316**	85.2	86.9
Calcium, Dissolved	29.7	48.3	31.2	33.5
Cadmium, Dissolved ug/L	<1.00	<1.00	<1.00	<1.00
Copper, Dissolved ug/L	21.4	29.2	24.8	**43.2 a,c**
Iron, Dissolved ug/L	<5.0	<5.0	<5.0	<5.0
Magnesium, Dissolved	18.2	30.2	19.2	20.5
Lead, Dissolved ug/L	<2.0	<2.0	<2.0	<2.0
Zinc ug/L	<5.00	7.01	<5.00	<5.00

3.3 Fine Sediment Percentage

The percentage of fine sediment ranged from as low as one percent in the upstream control quadrats to as much as 96 percent in Station #1 quadrats (Table 11, Figure 5). Fine sediment increased from upstream to downstream. The means for #3 and #2 were approximately nine percent, while #1 had approximately 30 percent fine sediment.

Table 11
Fine Sediment Observation Values (%) for Stations per Grid and Quadrat in September 2001. Six quadrats per site, 18 per station. **Bold**=trend of higher values

Grid-Quadrat	Big River #3 Reference Station September 2001 (%)	Big River #2 Test Station September 2001 (%)	Big River #1 Test Station September 2001 (%)
1-1	34	01	10
1-2	03	03	01
1-3	27	21	07
1-4	20	04	96
1-5	01	07	07
1-6	07	01	04
2-1	02	03	**21**
2-2	02	01	**50**
2-3	01	03	**25**
2-4	04	03	**31**
2-5	09	02	**20**
2-6	03	02	**12**
3-1	06	11	**53**
3-2	02	81	**33**
3-3	05	04	**07**
3-4	24	04	**19**
3-5	12	04	**95**
3-6	01	10	**61**
Mean Percentage	9.06	9.17	30.67

Statistical analysis revealed that fine sediment increased significantly between stations on the upper Big River. Kruskal-Wallis ANOVA on ranks (Sigmastat 2.0, 1997) showed a significant difference (H=13.879, d.f.=4, p=<0.001) between stations (Appendix D). Tukey's Test revealed that the percentages at the control station #3 (app. 9%) and Station #2 (app. 9%) were significantly lower (p<0.05) in percentage of fine sediment than the farthest downstream Station #1 (app. 30%). Furthermore, it appears that the percentage of fine sediment began to increase

within Station #1 at grid 2, which is approximately 0.25 miles upstream from the Cedar Creek confluence. Percentages within Station #1 increased further at grid 3, which is below the confluence with Cedar Creek (Table 11).

3.4 Fine Sediment Character
Fine sediment lead and zinc increased from upstream to downstream stations and grids (Figure 5, Appendix C). However, the fine sediment lead and zinc content did not reveal a significant change (lead - $H=1.689$, d.f.=2; $p=0.511$; zinc - $H=1.867$, d.f. =2; $p=0.439$; Appendix D). Interestingly, lead and zinc were found in their highest concentrations below the confluence with Cedar Creek (i.e. Station #1, grid 3, Appendix C).

4.0 Discussion
The discussion includes a habitat assessment, important macroinvertebrate analyses, physicochemical water variables, and fine sediment comparisons.

4.1 Habitat Assessment
Habitat scores declined from upstream to downstream, however, all stations were within the full sustainability category when compared to biological criteria reference streams. Habitat downstream in Station #1 was approximately 10 points lower than the upstream areas, probably due to land-use practices.

4.2 Macroinvertebrate Analyses
Macroinvertebrate analyses included an evaluation of metrics scores from upstream to downstream, examination of the dominant families, and a fine sediment comparison with generally intolerant macroinvertebrates.

4.2.1 Metrics Scores and Sustainability
We found that the variability between metrics scores was not outstanding. The total taxa and Shannon Diversity Index (SDI) were slightly lower at Station #1 in October, which accounted for the drop. Total Taxa and EPT taxa in April were lower at Station #2 as well. However, all of the stations scores were within a certain level of variability and do not suggest a problem exists at either test station.

Metrics scores and sustainability did not substantially change between seasons. All stations were considered as fully capable to sustain macroinvertebrate populations based on comparisons with biocriteria reference streams during both seasons. Numbers of total taxa and EPT taxa were higher in April, as one would expect because of spring emergence. Both suggest that there was not a detrimental influence on the stations above Cedar Creek.

4.2.2 Dominant Macroinvertebrate Families

In October 2001, the high percent occurrence of Ephemeroptera at #1 was mainly due to large numbers of mayflies in the family Tricorythidae. These mayflies are often abundant in the fall in habitats that contain greater quantities of silt and sand. As stated above (Table 11, Figure 5), Station #1 had the highest percentage of fine sediment of the three stations. The low numbers of stoneflies and caddisflies reflects the fact that stoneflies are mostly present in the spring and caddisflies are generally more numerous in larger streams and rivers.

In general, most spring (April 2002) macroinvertebrate samples from unimpaired biocriteria Ozark streams in the WQM database contain a 25th percentile of greater than 29 EPT taxa. Therefore, it is likely that these Big River Stations were unimpaired and were similar to biocriteria reference streams within the Ozark/Meramec EDU. The higher percent of caenid mayflies at Station #1 in April probably was due to the greater quantities of fine sediments at this station.

4.2.3 Fine Sediment and Macroinvertebrate Observation

Fine sediments apparently had an effect on the composition of the macroinvertebrate community. Figure 6 shows relatively constant amounts of fine sediment and similar numbers of EPT taxa and percentages of Ephemeroptera for stations #3 and #2. Interestingly, fine sediment increased at Station #1, while the number of EPT and percent Ephemeroptera also increased. (Table 7). The increase seems to contradict the assumption that fine sediment had an effect on the intolerant taxa. However, Table 7 and the macroinvertebrate bench sheets (Appendix B) show that the EPT number and percentage of Ephemeroptera potentially increased because of sediment tolerant Ephemeroptera, such as T*ricorythodes sp.* The number of heptageniid mayflies reduced slightly, as would be expected with an increase in fine sediment. The increase in fine sediment tolerant taxa may also have been due to an increase in the order of the stream at the confluence with Cedar Creek. Whatever the reason, the dominance of indicator taxa within the macroinvertebrate community changed from intolerant to tolerant species at the farthest downstream station.

4.3 Physicochemical Water

Most physicochemical variables were not exceptional. Two variables that were interesting were dissolved barium and copper. Furnace Creek may have had some influence on both.

4.3.1 Dissolved Barium Influence

It was apparent that Furnace Creek watershed continuously contributed dissolved barium into Big River (Figure 3). September 2001 and April 2002 dissolved levels were similar, while the July 2001 total recoverable barium level was also higher in Furnace Creek than all other stations. The abandoned strip mine may have been the source. Acceptable barium levels are not specified for the "protection of aquatic life" in the <u>Rules of the Department of Natural Resources</u>

(MDNR 10CSR 20-7.031, 2000) Water Quality Standards, based on the stream's classification as a General Warm Water Fisheries (GWWF). Standards are identified for public drinking water as less than 2000 ug/L. A study on Furnace Creek may determine its source for barium, and if Furnace Creek is impaired by dissolved barium.

4.3.2 Dissolved Copper Influence

Dissolved copper levels (43.2 ug/L) were discovered to be above acceptable levels for acute (43 ug/kg) and chronic (28 ug/kg) exposure at Station #1 during April 2002. The input of copper did not appear to be continuous because it was not detectable in the September sampling period. Discharge was 10 times higher in April, which may have contributed to the input. Water samples were taken upstream of the Cedar Creek confluence so it is not the apparent contributor. Furnace Creek contributed the next highest concentration of dissolved copper to Big River behind Station #1, although it is possibly not the only source. The source for copper should be examined further on Furnace Creek, as well as upstream Big River.

4.4 Fine Sediment Percent Influences

There appears to be one influence that significantly ($p<0.05$) increased the amount of fine sediment from upstream to downstream Big River. Again, concentrations of fine sediment at certain locations may point to its source.

Fine sediment increased from stations upstream to Station #1 (from 9 to 24 percent) above Cedar Creek (Table 11; Appendix D). The increase in the station above Cedar Creek suggests that there is a local influence or that it is a sediment trap. Whether or not it is local, the increase was not that great and was not significant over the control (Station #3). Likewise, 24 percent fine sediment is not a substantial portion of the substrate.

Another source for fine sediment for Big River appeared to be Cedar Creek itself. It appears that Cedar Creek added six percent of fine sediment to Station #1, which increased the total for Station #1 from 24 to 30 percent. This influenced a significant difference ($p<0.05$) that was found between station #1 versus stations #3 and #2 (Table 11, Appendix D). It also suggested that this amount was not a great increase over the sediment percentages found farther upstream in Station #1, nor was the increase very different from the control station (ca. 20%). The increase in the fine sediment percentage at this station may have been due to the increase in stream order at the confluence. Further fine sediment studies may be conducted in the Cedar Creek watershed to identify sources and examine levels of fine sediment.

4.4.1 Fine Sediment Character: Lead and Zinc Influence

Both lead and zinc in the sediment were constant and did not increase from upstream to downstream until Station #1, below Cedar Creek (Appendix D). While not significantly different, Station #1 was clearly higher in both lead and zinc found in the sediment composition. It appears that the fine sediment upstream of Cedar Creek in Station #1 was greatly influenced by

mining practices and does not seem to be more than background, if it is compared with the upstream control (Appendix C; Appendix D). However, lead and zinc increased below the confluence with Cedar Creek (Appendix C, grid 3), suggesting that its source may be mine related.

To be more specific, with the grid downstream of Cedar Creek (grid #3) omitted, the amount of lead deposited by Cedar Creek may be identified. Station #1 originally had the highest mean concentration of total recoverable lead at 21,566 ug/kg and the highest individual concentration of 29,400 ug/kg in the grid downstream from Cedar Creek (Appendix C). With the grid below Cedar Creek omitted, the mean for Station #1 (17,650 ug/kg) was closer to Stations #3 (16,233 ug/kg) and #2 (18,000 ug/kg). This suggests that Cedar Creek nearly doubled the amount of lead found in the sediment of Big River. This was probably a function of land-use in the Cedar Creek watershed. It may also have been a function of the increase in stream order at the confluence.

Cedar Creek seemed to have a zinc influence on Big River as well. With the grid downstream of Cedar Creek omitted, zinc in the sediment decreased from a mean of 46,400 ug/kg to 39, 850 ug/kg (Appendix C). The mean was then very similar to stations #3 (33,533 ug/kg) and #2 (33, 967 ug/kg). This suggests that Cedar Creek added a mean of approximately 30 percent of the zinc found in upper Big River. Again, the increase may have been due to stream order at the confluence of Cedar Creek.

Despite the increase, lead concentrations were not above probable effects levels (PELs) of 86,000 ug/kg suggested by Ingersoll et al. (1996). Zinc was also below the PEL of 540,000 ug/kg.

5.0 Conclusion

The purpose of the study was to determine if Big River was impaired by a Furnace Creek area barium mine. While it apparently did contribute dissolved barium in low concentrations, Furnace Creek did not appear to have an effect on Big River macroinvertebrate communities. Furnace Creek may have contributed dissolved copper to Big River, but was probably not the only source. Copper was found upstream of Furnace Creek on Big River. The upper Big River reach was not affected by sediment related variables above the confluence with Cedar Creek. The macroinvertebrate community of upper Big River, above the mouth of Cedar Creek, may be considered similar to biological reference streams within the EDU.

Another stream within the study area may have an effect on Big River. Cedar Creek apparently contributes fine sediment, lead, and zinc to the substrate downstream from its confluence with Big River. The percentage of fine sediment was significantly greater downstream of Cedar Creek, however, it only adds approximately six percent on average of fine sediment from

immediately upstream of the confluence. Lead and zinc increased at Cedar Creek as well, however, concentrations were not above acceptable levels (PELs).

The objectives were met in this project. The macroinvertebrate communities and water quality seem to be relatively unaffected by the mining influence. Fine sediment and heavy metals were present in Big River downstream from the study area in low concentrations possibly due to Cedar Creek. Finally, aquatic habitat was fully capable of supporting aquatic communities.

6.0 Recommendations

Determine the location of the source for dissolved copper.

Conduct a study to determine if Furnace Creek was impaired by dissolved barium, copper, other metals, or fine sediment.

Conduct a bioassessment and sediment study on Cedar Creek, Washington County to determine extent and source for fine sediment, lead, and zinc.

Consider the upper Big River a candidate for wadeable/perennial biological criteria reference streams.

7.0 Literature Cited

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Figure 1: Study area control (3), test stations (2 and 1), and location of potential mine influence on Big River, Washington County.

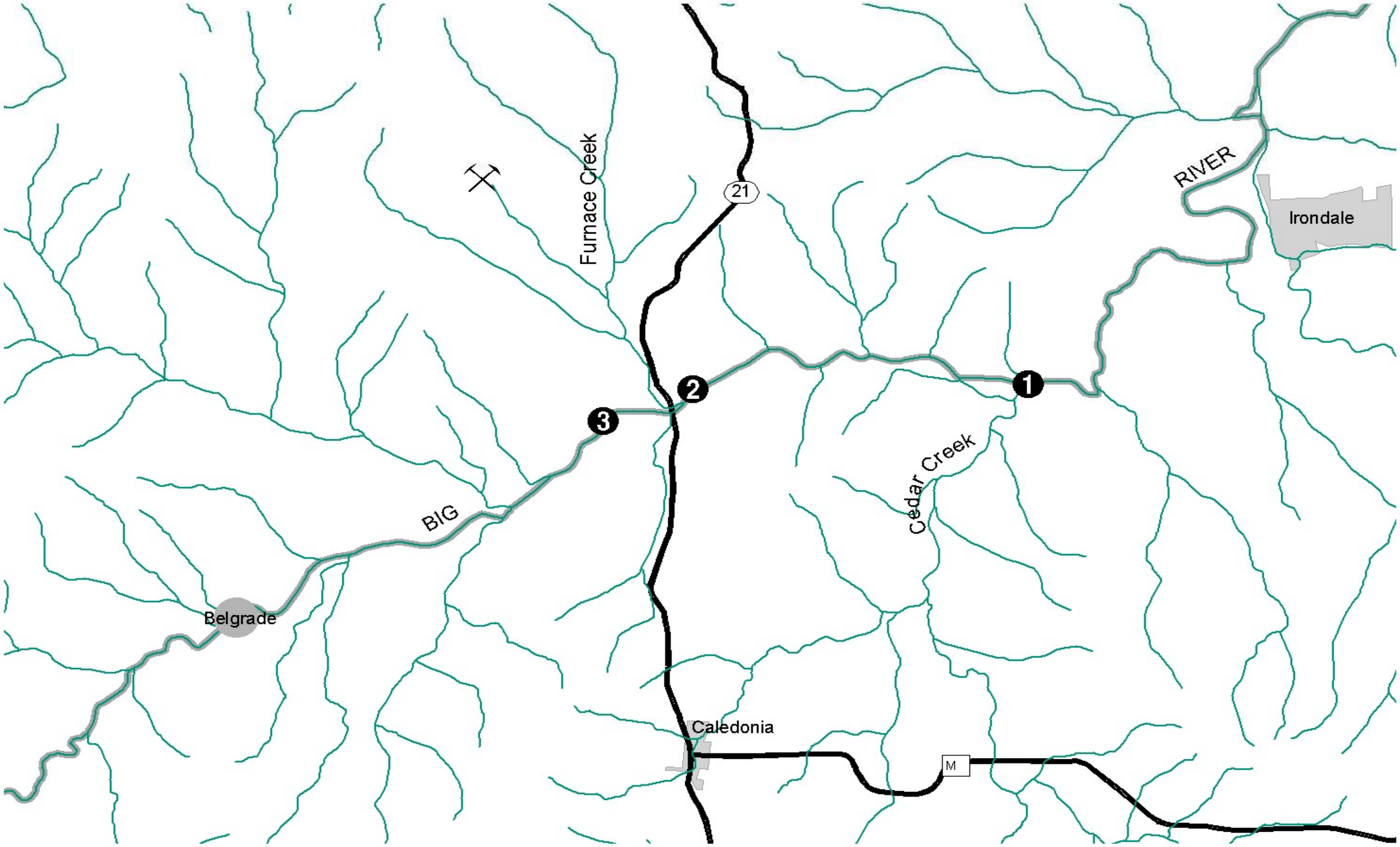
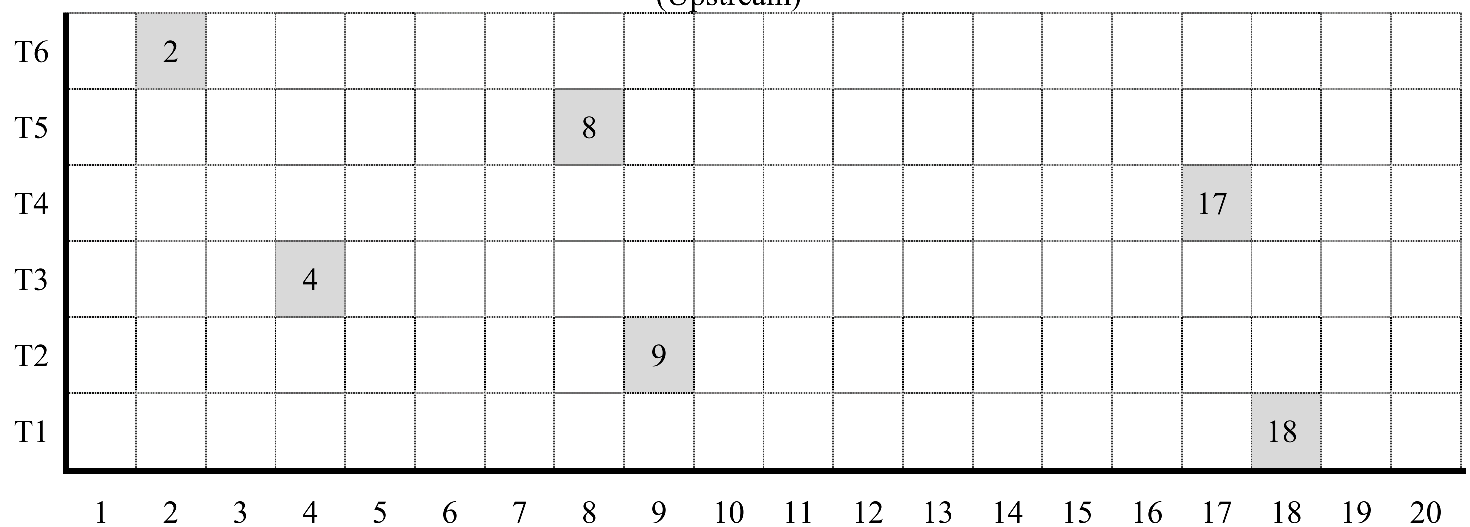


Figure 2: Grid of transects (T) and quadrats (in gray, numbered) for estimating percent fine sediment.
Example: stream 20’ wide; quadrat placement based on random numbers (e.g. 18, 9, 4, 17, 8, 2).

RIFFLE

(Upstream)



Tape Measure Reading
(feet)

POOL

Figure 3: Dissolved barium concentrations per station and season

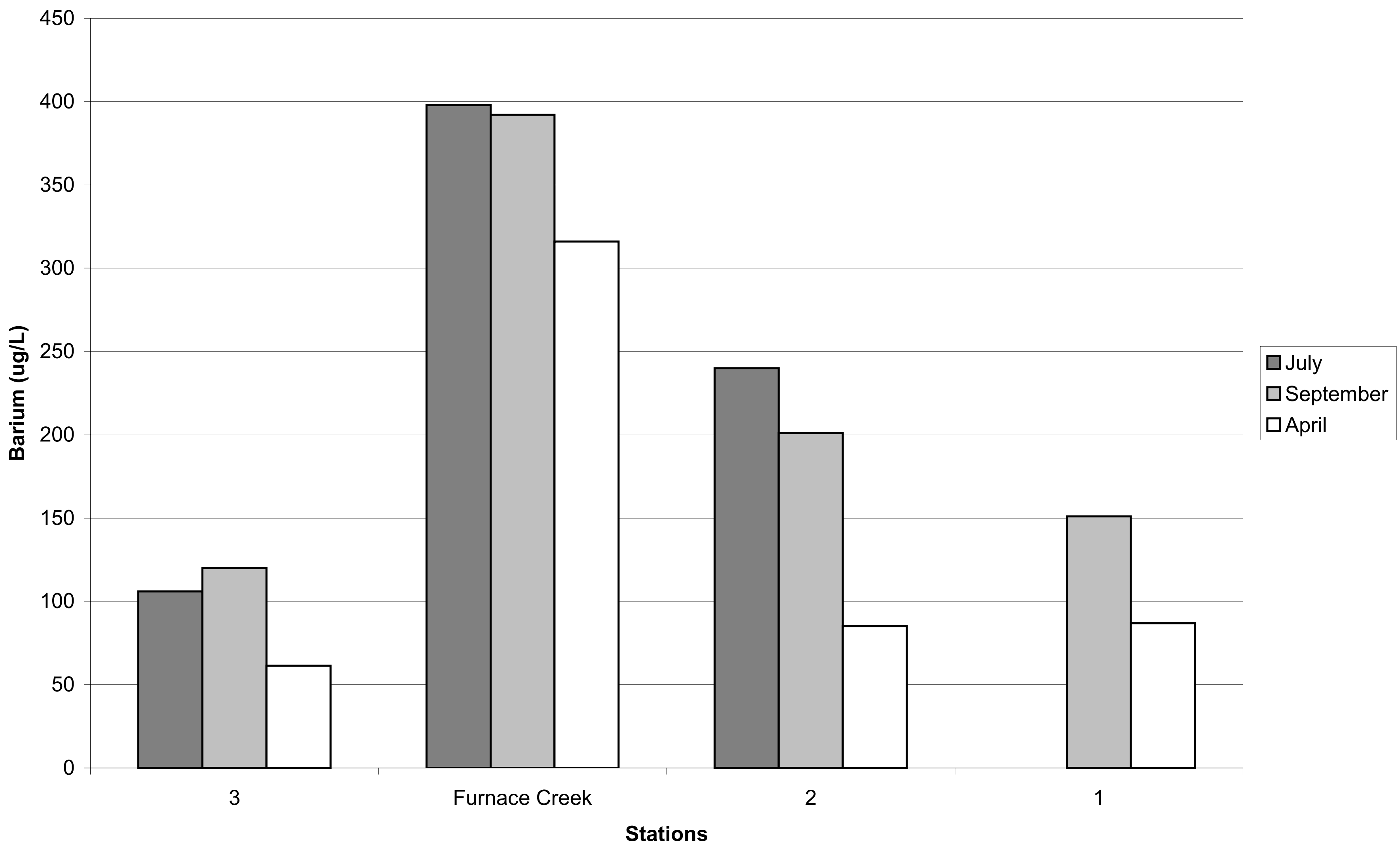


Figure 4: Dissolved copper concentrations per station and season; Acute and Chronic toxicity levels (MDNR 2000) at given hardness (CaCO3)

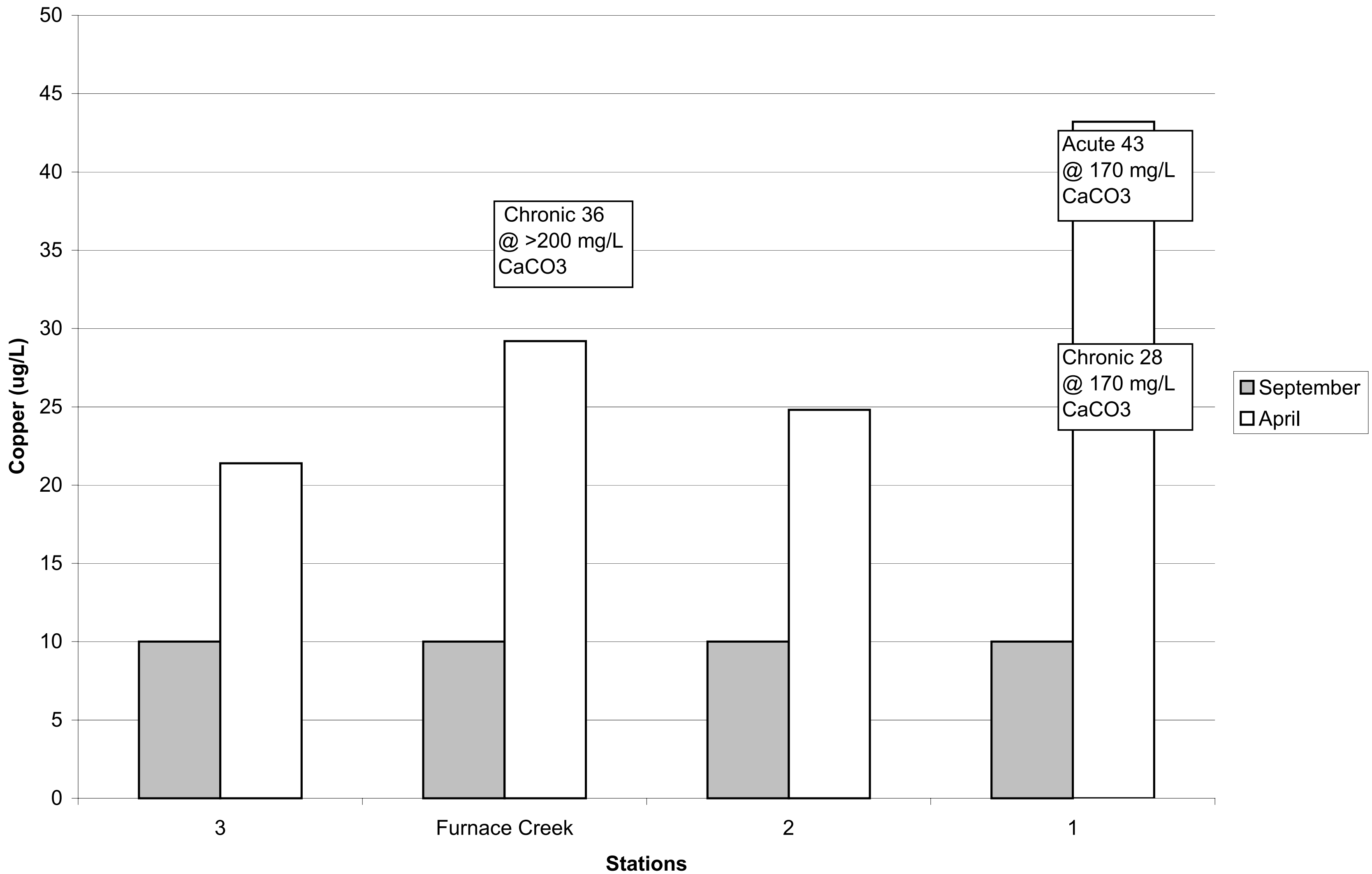


Figure 5: Fine sediment average percentage with lead and zinc levels per station

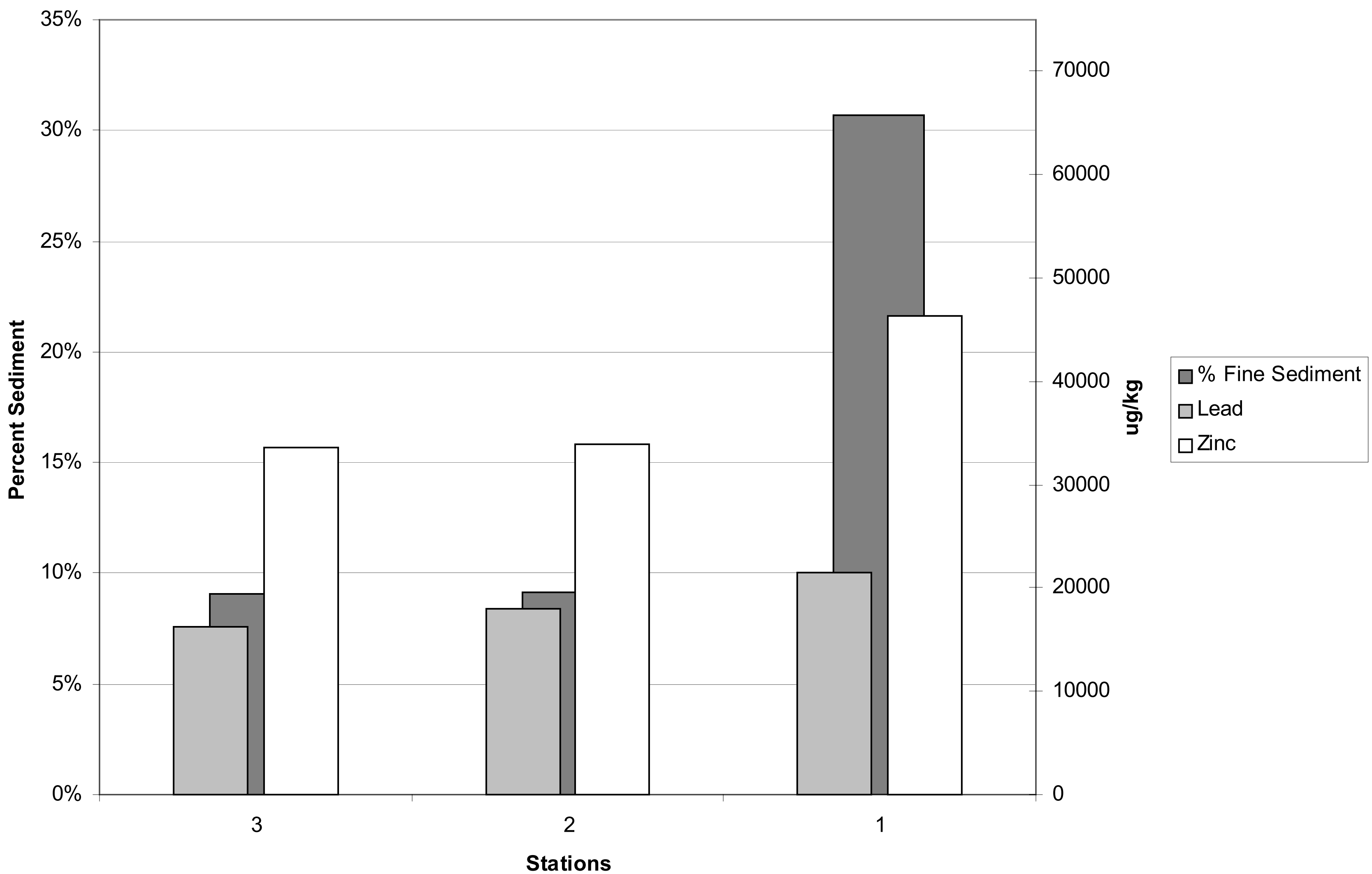
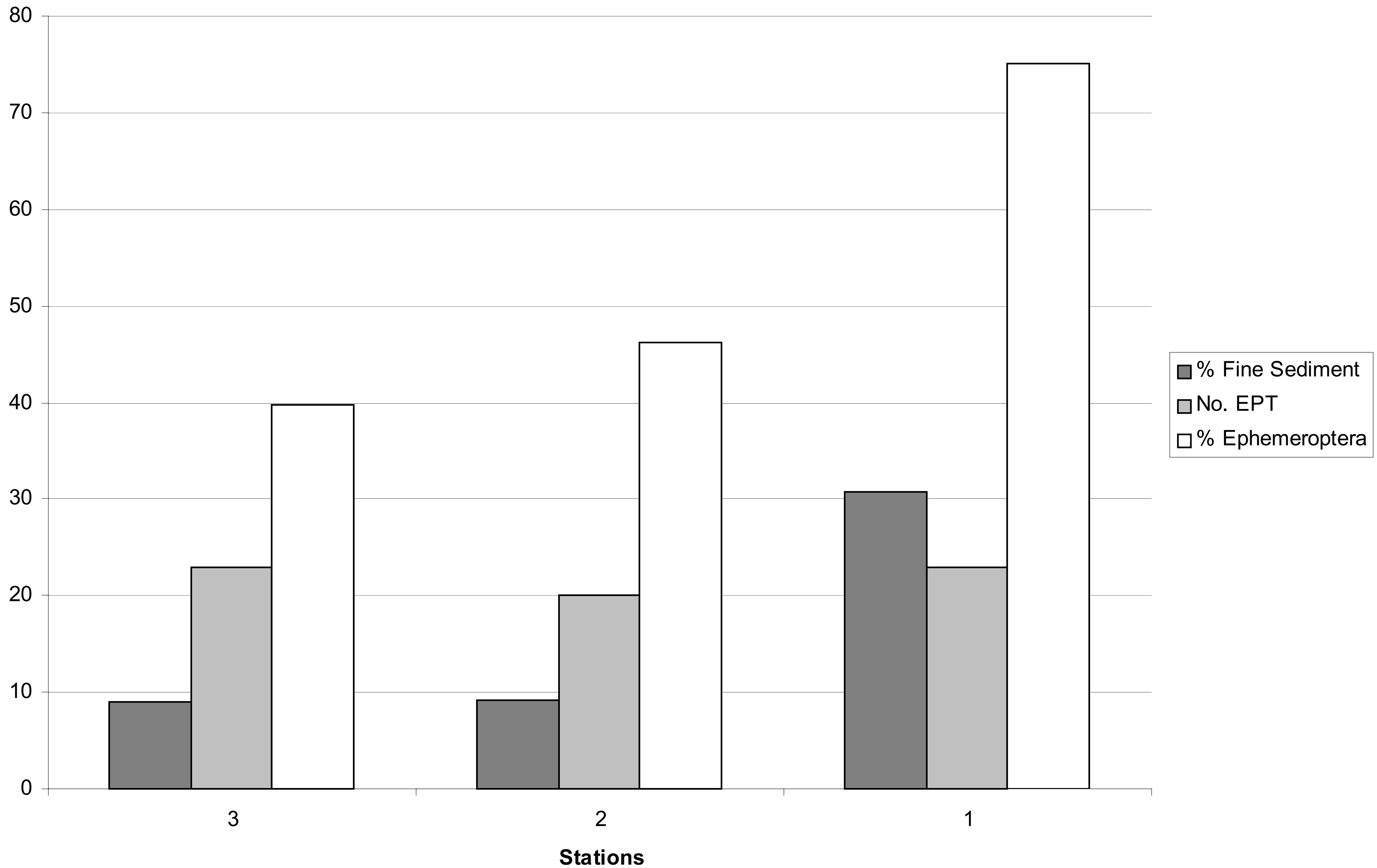


Figure 6: Fine sediment average percentage with number of EPT and percent Ephemeroptera



Appendix A

Missouri Department of Natural Resources
Bioassessment and Sediment Study Proposal
Big River, Washington County

Revised December 11, 2001

Missouri Department of Natural Resources
Bioassessment and Sediment Study Proposal for
Big River, Washington County

Revised
December 11, 2001

Objectives

1) Conduct a bioassessment on Big River, Washington County, a TMDL 303(d) listed stream.

2) Conduct a sediment assessment on Big River.

Null Hypotheses

Macroinvertebrate metrics will meet criteria similar to those of reference streams of the Meramec Ecological Drainage Unit (EDU).

Water quality is similar between stations or between Big River and reference streams.

No significant difference (p>0.05) in the sediment percentage estimates between control and test sites and the character of sediments is similar between control and test sites.

Background

Approximately 80 miles of Big River, Washington County is 303(d) listed for excessive sediment deposition and high lead and zinc values. Water runoff during rain events erodes mine wastes which has increased sedimentation in some lower portions of Big River. Portions of the stream were covered by fine-sediments that virtually eliminated aquatic habitats used by some invertebrates. Metals such as copper, iron, lead, and zinc have been detected in aquatic fauna in areas of Big River. While runoff of mine wastes may have effected portions of Big River, it is not known if the upper reaches have been impacted by similar potential hazards. In fact, there is only one known mine from the upper reaches of the stream that may have an effect on the upper reaches of Big River (Figure 1). A bioassessment and sediment assessment study will be conducted bracketing this single potential mine influence.

Study Methods

General: The study area is approximately 8.5 miles of Big River, Washington County. The upstream boundary is below Missouri Highway 32 at Belgrade, Missouri, while its downstream boundary is 0.25 miles downstream of the confluence with Cedar Creek, Washington County (Figure 1). Boundaries were determined based on watershed areas similar to the average biocriteria small river flow category.

Three stations will be sampled within the study area. Each station consists of a length of twenty-times the stream's average width, with at least two riffle reaches, as outlined in MDNR-FSS-030. One station will be upstream from all known mining influences (i.e. Control Station). The two remaining stations (i.e. Test Stations) will be below the confluence with Furnace Creek, which contains a single barite mine in the watershed (Figure 1). Sampling will occur in the fall of 2001, between September 15 and October 15, 2001.

Bioassessment: Macroinvertebrates will be sampled according to Standard Operating Procedures (SOP) MDNR- FSS-030 Semi-quantitative Macroinvertebrate Stream Bioassessment Procedure. Big River, Washington County is considered a "Riffle/Pool" predominant stream and habitats will be sampled accordingly. Habitats included in these streams are coarse substrate, non-flow, and rootmat.

Habitat Sampling: Stream flow and discharge will be measured using a Marsh-McBirney Flow Meter at the upstream and downstream extents of the study area. Stream habitat assessments will also be conducted within the study area in accordance with MDNR-FSS-032.

Water Quality Sampling: Water samples will be collected for identification of dissolved metals and nutrients from three Big River stations and Furnace Creek. A one-liter (L) sample will be collected for barium, cadmium, copper, iron, lead, zinc, calcium, magnesium, and hardness analyses. This water will be filtered through a 0.45 micron filter and preserved with nitric acid in the field. A second sample (1 L) will be collected for sulfate and chloride analyses. A third sample (1 L) will be collected for Total Kjeldahl Nitrogen (TKN), ammonia-nitrogen, nitrite plus nitrate nitrogen, and total phosphorus and will be preserved with sulfuric acid. In addition, two (2) 20 ml samples will be collected to measure turbidity. All samples will be kept on ice until they are delivered to the MDNR-Environmental Services Program (ESP), Chemical and Analytical Section (CAS) in Jefferson City, Missouri.

Dissolved oxygen, pH, conductivity, and temperature will be measured once at all three stations on Big River as well as the Furnace Creek location.

Sediment Percentage and Characterization: To ensure sampling method uniformity, depositional areas sampled will be in-stream at the upper margins of pools and lower margins of riffle/run habitat. Depths of the sample areas will not exceed two (2.0) feet and water velocity will be less than 0.5 feet per second (fps). A Marsh McBirney flow meter will be used to ensure that water velocity of the sample area is within this range.

In-stream deposits of fine sediment (i.e. less than particle size ca. 2mm=coarse sand) will be (1) estimated for percent coverage per area and (2) characterized by chemical analysis for total recoverable metals (TRM).

A visual method will be used to estimate the percentage of fine sediment. Each sampling station shall be composed of three sample areas (i.e. grids), each consisting of six contiguous transects across the stream. A tape measure will be stretched from bank to bank at each transect. One sample quadrat (ca. 10 x 10 inches) will be placed directly on the substrate within each of the six transects using a random number that equates to one foot increments. The trailing edge of the

quadrat will be placed on the random foot increment. Two investigators will estimate the percentage of the stream bottom covered by fine sediment within each quadrat. If the estimated percentages are within ten percent between investigators, they will be accepted. If estimates diverge more than ten percent, the investigators will repeat the process until the estimates are within the acceptable margin of error. An average of these two estimates will be recorded and used for analysis.

Sediment will be characterized by determining the content of total recoverable metals (TRM) at each of the transect-grids. Specifically, sediments will be analyzed for lead and zinc content. Composite collections will be taken within each transect-grid of sediments that are similar in appearance to the sediment estimated earlier for percentage. If amounts of sediment are too small within the grid, a representative composite collection will be taken from an area near the study grid. Each composite will consist of three (3) two-ounce grab samples of sediment. One (1) two-ounce glass jar will be used as a collection device to dredge the bottom to a depth, within the sediment, of no more than two inches. In order to retain the fine sediment, the sediment sample will be held inside the jar for removal from the water column by covering the opening with the back of the cap. Each sample will be deposited into an eight-ounce glass jar comprising a composite for each transect-grid. There will be three transect-grids per station in order to more accurately characterize and lessen potential bias. Each composite jar will be placed on ice for transport to the ESP Lab according to SOP, MDNR-FSS-001.

Laboratory Methods: Analyses of biological and chemical samples will be conducted at the MDNR Environmental Services Program (ESP) laboratory in Jefferson City, Missouri. Biological samples will be processed and identified according to MDNR-FSS-209 Taxonomic Levels for Macroinvertebrate Identifications. The MDNR ESP environmental laboratory will conduct water quality analyses for dissolved metals as well as for total recoverable metals (TRM) on the sediment samples. Turbidity will be quantified in the biology/toxicology lab at the ESP.

Data Analysis: Macroinvertebrate data will be entered into a Microsoft Access database according to the MDNR Standard Operating Procedure MDNR-WQMS-214, Quality Control Procedures for Data Processing. Data analysis is automated within the Access database. Four standard metrics are calculated according to the Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (SMSBPP). Total Taxa (TT), Ephemeroptera, Plecoptera, Trichoptera Taxa (EPTT), Biotic Index (BI), and the Shannon Index (SI) will be calculated for each station. Additional metrics, such as percent Similarity of Taxa, may be employed to discern differences in taxa between control and test stations. Macroinvertebrate data from reference streams within the Meramec EDU will allow for the calculation of a 25th percentile for the four metrics in the SMSBPP. Big River will be scored against these calculations and a composite score of 16 or greater will determine non-impairment.

The percentage of sediment deposition may be compared between stations, sites, or grids. This will be done by parametric comparisons of means, correlation, or non-parametric methods at a significant probability level ($p<0.05$).

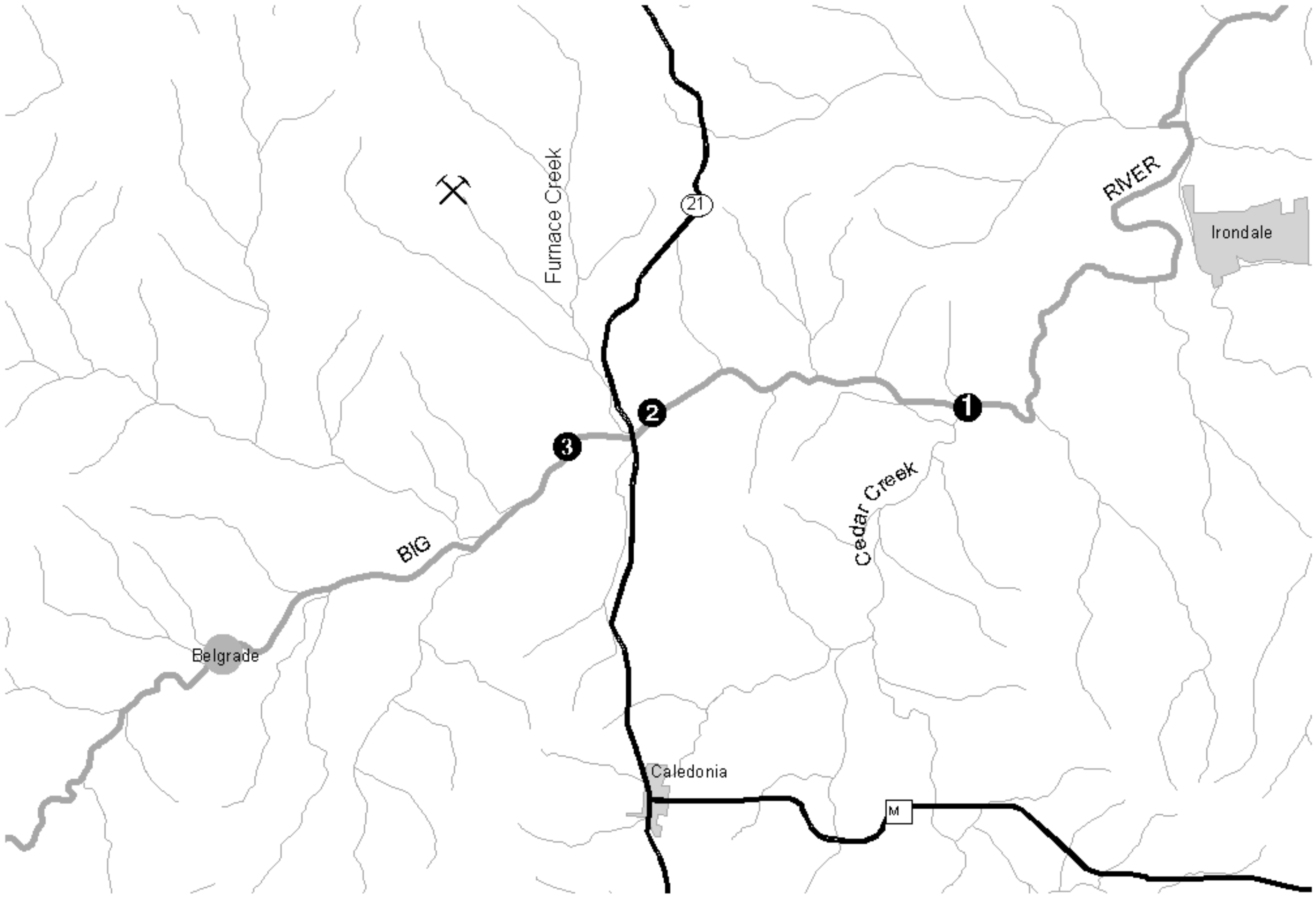
Ordination of communities with multiple linear regression may be used in conjunction with habitat assessment, water quality values, and sediment percentages as well as character of sediments in order to correlate with environmental variables.

Data Reporting: A report will be written for the Water Pollution Control Program (WPCP) which outlines and interprets the results of the study.

Quality Controls: As stated in the various MDNR Project Procedures and Standard Operating Procedures.

Attachments: Figure 1: Study area control, test stations, and location of potential mine influence on Big River, Washington County.

Figure 1: Study area control (3), test stations (1 and 2), and location of potential mine influence on Big River, Washington County.



Appendix B

Macroinvertebrate Bench Sheets for Upper Big River, October 2001 and April 2002

Key: CS=Coarse substrate habitat, (i.e. riffle), NF=Non-Flow habitat (i.e. pools), RM=Root-mat habitat, *=Large/Rare presence

Big River Stations	3	3	3	3	2	2	2	2	1	1	1	1
October 2001												
Sample Number	137077	137077	137077	TOTAL	137076	137076	137076	TOTAL	137078	137078	137078	TOTAL
Habitat	CS	NF	RM		CS	NF	RM		CS	NF	RM	
Miscellaneous												
Acarina	13	11	1	25	49	4	2	55	48		3	51
Aulodrilus						1		1				
Enchytraeidae												
Gordiidae			*									
Ilyodrilus templetoni												
Limnodrilus cervix												
Limnodrilus hoffmeisteri												
Lumbricidae		*			1	1		2				
Lumbriculidae	3			3	2			2				
Planariidae	2	1		3	1	5	2	8	2	1		3
Tubificidae		1		1		7		7				
Crustacea												
Caecidotea												
Hyalella azteca			202	202			50	50			7	7
Orconectes hylas	3			3	*							
Orconectes luteus	*		*		*	1		1		1		1
Orconectes virilis										*		
Stygobromus		1		1								
Mollusca												
Ancylidae	3	4	1	8	3	1	1	5				
Corbicula												
Elimia	15	8	22	45	2	15	86	103	3	3	3	9
Ferrissia									20			20
Fossaria									1			1
Gyraulus												
Helisoma			7	7							16	16
Menetus	1			1		1		1	1	6	3	10
Physella			1	1			5	5			1	1
Sphaeriidae		1		1						1		1
Sphaerium					1			1				
Ephemeroptera												
Acentrella	3			3								
Anthopotamus												
Baetis	44			44	10			10	4			4
Baetisca lacustris												
Caenis anceps	10	34		44	7	74		81	2	120		122
Caenis latipennis		9	3	12	10		5	15	27	43	37	107
Centroptilum			3	3		2		2			1	1
Choroterpes										1		1

Big River Stations	3	3	3	3	2	2	2	2	1	1	1	1
October 2001												
Sample Number	137077	137077	137077	TOTAL	137076	137076	137076	TOTAL	137078	137078	137078	TOTAL
Habitat	CS	NF	RM		CS	NF	RM		CS	NF	RM	
Ephemerella needhami												
Eurylophella	5	5		10	1			1	7			7
Eurylophella bicolor												
Heptageniidae	105	1		106	31	18		49	103	3		106
Isonychia bicolor	103			103	114			114	227			227
Leptophlebia												
Leptophlebiidae	2	16	1	19		2		2				
Paraleptophlebia												
Procloeon		1	1	2		5	5	10				
Siphlonurus												
Stenacron	2			2						3		3
Stenonema femoratum		11		11		15		15		14		14
Stenonema mediopunctatum	136			136	83			83	240		1	241
Stenonema pulchellum	15			15	9			9	32			32
Tricorythodes	20	5		25	209	2		211	954	5	3	962
Odonata												
Argia	23	16	8	47	11	17	3	31	15	6	3	24
Arigomphus												
Basiaeschna janata			*			*	1	1				
Boyeria												
Calopteryx							2	2				
Enallagma			6	6		8	41	49		2	20	22
Epitheca (Tetragoneuria)												
Gomphidae	15	7		22	6			6	6	4		10
Gomphus						1		1				
Hagenius brevistylus		6		6		1		1		3		3
Hetaerina												
Macromia		1		1							*	
Stylogomphus albistylus		*			1	1		2		1		1
Plecoptera												
Acroneuria												
Allocapnia												
Amphinemura												
Isoperla												
Leuctridae												
Neoperla	2			2								
Perlesta												
Perlidae					2			2				
Perlinella ephyre												
Prostoia												

Big River Stations	3	3	3	3	2	2	2	2	1	1	1	1
October 2001												
Sample Number	137077	137077	137077	TOTAL	137076	137076	137076	TOTAL	137078	137078	137078	TOTAL
Habitat	CS	NF	RM		CS	NF	RM		CS	NF	RM	
Megaloptera												
Corydalus	2			2	2	*		2	2			2
Nigronia serricornis						*						
Sialis		1		1		1		1		*		
Tricoptera												
Agapetus												
Ceratopsyche morosa grp									2			2
Cheumatopsyche	8			8					9			9
Chimarra	4	1		5	2			2		1		1
Helicopsyche	1			1	2			2				
Hydropsyche									1			1
Hydroptila		2	4	6		1		1			1	1
Mystacides												
Nectopsyche						4	2	6	1	1		2
Ochrotrichia												
Oecetis	2			2		1	2	3	1	1	9	11
Orthotrichia												
Oxyethira			2	2							2	2
Polycentropodidae											1	1
Polycentropus												
Rhyacophila												
Triaenodes		3	19	22			10	10			5	5
Coleoptera												
Ancyronyx variegatus			1	1								
Berosus						1		1			1	1
Dubiraphia		40	11	51		55	11	66	1	10	44	55
Dytiscidae												
Ectopria nervosa	2	8	1	11	*	9	3	12	2	11		13
Helichus lithophilus	1			1			4	4	1		*	1
Hydroporus												
Macronychus glabratus							3	3			2	2
Microcylloepus pusillus												
Optioservus sandersoni	15	1		16	15			15	24	2		26
Oreodytes												
Paracymus												
Psephenus herricki	79	15		94	28	5		33	4	1	1	6
Scirtes			2	2			1	1				
Stenelmis	4	20		24	16	15	5	36	67	12	1	80
Chironomidae												
Ablabesmyia		10	6	16		8	4	12		2	7	9

Big River Stations	3	3	3	3	2	2	2	2	1	1	1	1
October 2001												
Sample Number	137077	137077	137077	TOTAL	137076	137076	137076	TOTAL	137078	137078	137078	TOTAL
Habitat	CS	NF	RM		CS	NF	RM		CS	NF	RM	
Apedilum							1	1				
Cardiocladius									1			1
Chironomus		1		1						4		4
Cladotanytarsus										1		1
Clinotanypus												
Corynoneura	1			1	2	4		6	2	2	2	6
Cricotopus bicinctus										2	3	5
Cricotopus/Orthocladius	4		6	10	9	3	4	16	14	4	25	43
Cryptochironomus		1		1			1	1				
Dicrotendipes		4	1	5	1		1	2		2		2
Eukiefferiella												
Eukiefferiella brevicalcar grp												
Glyptotendipes												
Hydrobaenus												
Labrundinia			6	6		2		2		1	5	6
Larsia												
Micropsectra												
Microtendipes		1		1								
Nanocladius			17	17			1	1			3	3
Orthocladius (Euorthocladius)												
Paracladopelma						1		1				
Parakiefferiella	1			1								
Paramerina												
Parametriocnemus		1		1								
Paratanytarsus	1	3	24	28		8	12	20		5	61	66
Paratendipes		1		1								
Phaenopsectra							1	1		1		1
Polypedilum convictum grp	5			5	3			3				
Polypedilum halterale grp						1		1				
Polypedilum illinoense grp			2	2			3	3		1	1	2
Polypedilum scalaenum grp												
Potthastia												
Procladius						1		1				
Pseudochironomus		12	2	14		3		3		1		1
Pseudorthocladius												
Rheocricotopus	2			2								
Rheotanytarsus	3	2	1	6	8	1		9	12		5	17
Stempellinella	1	9		10	3	2		5		3		3
Stenochironomus	1	1		2	4			4				
Stictochironomus												
Sympotthastia												
Tanytarsus	7	5	21	33	8	22	12	42	7	7	11	25
Thienemanniella						1		1	1		3	4

Big River Stations	3	3	3	3	2	2	2	2	1	1	1	1
October 2001												
Sample Number	137077	137077	137077	TOTAL	137076	137076	137076	TOTAL	137078	137078	137078	TOTAL
Habitat	CS	NF	RM		CS	NF	RM		CS	NF	RM	
Thienemannimyia grp.	2	3	1	6		1		1		1		1
Tribelos		2		2		21		21				
Tvetenia bavarica grp												
Zavreliella												
Zavrelimyia												
Diptera												
Atherix		*			1			1				
Ceratopogoninae			3	3		1		1		1	1	2
Clinocera												
Diptera												
Forcipomyiinae												
Hemerodromia	2			2	1			1	2			2
Hexatoma												
Nemotelus												
Ormosia												
Prosimulium												
Simulium	2			2	2			2	1			1
Stratiomys												
Tabanus						*						
Tipula									*			
Lepidoptera												
Petrophila	1			1	2	2		4				
Pyralidae												
Total Individuals	676	286	386	1348	662	356	284	1302	1847	294	292	2433
Taxa Richness	46	46	34	78	41	51	31	80	38	43	36	70

Big River Stations	3	3	3	3	2	2	2	2	1	1	1	1
April 2002												
Sample Number	218023	218023	218023	TOTAL	218024	218024	218024	TOTAL	218025	218025	218025	TOTAL
Habitat	CS	NF	RM		CS	NF	RM		CS	NF	RM	
Miscellaneous												
Acarina	14	18	4	36	19		2	21	7	28	9	44
Aulodrilus												
Enchytraeidae		1		1		2		2	2	3		5
Gordiidae												
Ilyodrilus templetoni										4		4
Limnodrilus cervix		2		2								
Limnodrilus hoffmeisteri		1		1								
Lumbricidae	16	4	2	22	10	1		11		1		1
Lumbriculidae										1		1
Planariidae	5			5	4			4	2	1		3
Tubificidae		8		8		2	2	4		1		1
Crustacea												
Caecidotea									1		1	2
Hyalella azteca		2	43	45					1	1	8	10
Orconectes hylas												
Orconectes luteus	*	*	2	2							*	
Orconectes virilis							*				*	
Stygobromus											1	1
Mollusca												
Ancylidae					2			2			1	1
Corbicula										1		1
Elimia	17	1	17	35	8	2	15	25	2	2	6	10
Ferrissia												
Fossaria									1			1
Gyraulus											1	1
Helisoma	2		*	2					1		*	1
Menetus												
Physella		1	*	1		*					1	1
Sphaeriidae		3		3	1			1				
Sphaerium									3	3		6
Ephemeroptera												
Acentrella	73		9	82	63		7	70	117		6	123
Anthopotamus						2		2	*			
Baetis												
Baetisca lacustris		*				*			1		1	2
Caenis anceps												
Caenis latipennis	34	50	41	125	30	19	42	91	53	106	61	220
Centroptilum			3	3		1	8	9		1	3	4
Choroterpes												

Big River Stations	3	3	3	3	2	2	2	2	1	1	1	1
April 2002												
Sample Number	218023	218023	218023	TOTAL	218024	218024	218024	TOTAL	218025	218025	218025	TOTAL
Habitat	CS	NF	RM		CS	NF	RM		CS	NF	RM	
Ephemerella needhami			2	2	1			1	2			2
Eurylophella												
Eurylophella bicolor	12	15	17	44	1	9	16	26	10	6	6	22
Heptageniidae	123	5		128	16	5	2	23	32		1	33
Isonychia bicolor	13			13	4			4	28			28
Leptophlebia		8	10	18		14	21	35	1	3	2	6
Leptophlebiidae	4			4								
Paraleptophlebia							1	1	1			1
Procloeon												
Siphlonurus											1	1
Stenacron	2			2		14		14	1			1
Stenonema femoratum	11	11		22	2	46	2	50	17	6		23
Stenonema mediopunctatum					5	3		8	17			17
Stenonema pulchellum	22	2	1	25	5	6	4	15	4			4
Tricorythodes	2			2	3		1	4	14	4	1	19
Odonata												
Argia	3	1	1	5		4	2	6		1		1
Arigomphus						1		1				
Basiaeschna janata		*	*									
Boyeria							1	1			1	1
Calopteryx			1	1			1	1		1		1
Enallagma			8	8		2		2		3	5	8
Epitheca (Tetragoneuria)											*	
Gomphidae	6			6	8	1		9	1	2		3
Gomphus												
Hagenius brevistylus		1		1		*						
Hetaerina											1	1
Macromia												
Stylogomphus albistylus		1		1			*					
Plecoptera												
Acroneuria			*			1		1				
Allocapnia									2			2
Amphinemura	7		5	12	13			13	7			7
Isoperla	2			2								
Leuctridae	25	2		27	4		1	5		2		2
Neoperla	3	1		4		2		2	1			1
Perlesta					1			1	2		1	3
Perlidae			2	2								
Perlinella ephyre									1			1
Prostoia	1			1								

Big River Stations	3	3	3	3	2	2	2	2	1	1	1	1
April 2002												
Sample Number	218023	218023	218023	TOTAL	218024	218024	218024	TOTAL	218025	218025	218025	TOTAL
Habitat	CS	NF	RM		CS	NF	RM		CS	NF	RM	
Megaloptera												
Corydalus	*				1			1	1			1
Nigronia serricornis		*										
Sialis												
Tricoptera												
Agapetus					2			2				
Ceratopsyche morosa grp												
Cheumatopsyche	1		2	3	7			7	3			3
Chimarra	8		1	9	3	1		4	2			2
Helicopsyche	2			2								
Hydropsyche												
Hydroptila			7	7	12		2	14				
Mystacides	1			1								
Nectopsyche											2	2
Ochrotrichia			2	2								
Oecetis												
Orthotrichia	2			2						1		1
Oxyethira											1	1
Polycentropodidae												
Polycentropus	2			2			1	1				
Rhyacophila	3			3								
Triaenodes			1	1			2	2	1	1	4	6
Coleoptera												
Ancyronyx variegatus		1		1							1	1
Berosus	1			1					1	1		2
Dubiraphia		14	6	20	5	12	2	19	1	22	1	24
Dytiscidae	1		2	3								
Ectopria nervosa									1	1		2
Helichus lithophilus												
Hydroporus			1	1	1			1		1	1	2
Macronychus glabratus												
Microcylloepus pusillus					2	4		6				
Optioservus sandersoni	9			9	6			6	1			1
Oreodytes			1	1		1	1	2				
Paracymus		1		1	1			1	1			1
Psephenus herricki	26	4		30	9	2	*	11				
Scirtes												
Stenelmis	33	5		38	79	9		88	92	17	2	111
Chironomidae												
Ablabesmyia	1	10	1	12		17	3	20		8	2	10

Big River Stations	3	3	3	3	2	2	2	2	1	1	1	1
April 2002												
Sample Number	218023	218023	218023	TOTAL	218024	218024	218024	TOTAL	218025	218025	218025	TOTAL
Habitat	CS	NF	RM		CS	NF	RM		CS	NF	RM	
Apedilum												
Cardiocladius												
Chironomus		1		1								
Cladotanytarsus		8	1	9		1		1		1		1
Clinotanypus										1		1
Corynoneura		1	3	4		2	1	3			1	1
Cricotopus bicinctus			4	4			3	3				
Cricotopus/Orthocladius	13	34	62	109	35	18	63	116	30	11	30	71
Cryptochironomus		1		1						2		2
Dicrotendipes			1	1		2	1	3		2		2
Eukiefferiella						2		2	16	2	3	21
Eukiefferiella brevicalcar grp	18	19	10	47	106	2	4	112				
Glyptotendipes						1		1				
Hydrobaenus		3	2	5		3	2	5	1		1	2
Labrundinia		2	6	8		1	17	18		2	24	26
Larsia						2		2				
Micropsectra	1			1					1			1
Microtendipes		4		4						2	1	3
Nanocladius												
Orthocladius (Euorthocladius)					4			4				
Paracladopelma												
Parakiefferiella						2		2				
Paramerina						1		1				
Parametriocnemus	6	7		13	5			5	5	1		6
Paratanytarsus		1	16	17	1		12	13	3	2	16	21
Paratendipes		9		9						10		10
Phaenopsectra			1	1						2		2
Polypedilum convictum grp	13	14		27	10			10	22			22
Polypedilum halterale grp												
Polypedilum illinoense grp	1			1			1	1				
Polypedilum scalaenum grp										2		2
Potthastia			2	2			1	1		1		1
Procladius		1		1						1		1
Pseudochironomus		2	1	3					1	1		2
Pseudorthocladius						1		1				
Rheocricotopus	3	1	1	5	3	1	2	6	5	1	2	8
Rheotanytarsus			1	1	7			7			2	2
Stempellinella	1	5		6	2	12		14	2	15	4	21
Stenochironomus												
Stictochironomus		2		2								
Sympotthastia	5		18	23	2	3	29	34	5	1	8	14
Tanytarsus		6	2	8	2	7	3	12	5	17	2	24
Thienemanniella			1	1			1	1	1	1		2

Big River Stations	3	3	3	3	2	2	2	2	1	1	1	1
April 2002												
Sample Number	218023	218023	218023	TOTAL	218024	218024	218024	TOTAL	218025	218025	218025	TOTAL
Habitat	CS	NF	RM		CS	NF	RM		CS	NF	RM	
Thienemannimyia grp.	8	16	4	28	1	6	4	11	7	6	2	15
Tribelos						2	1	3		2		2
Tvetenia bavarica grp					1			1				
Zavreliella		1		1						3		3
Zavrelimyia						3	1	4		1		1
Diptera												
Atherix												
Ceratopogoninae		14		14	3			3	1	7		8
Clinocera	25	3	1	29	4	2		6	3	3		6
Diptera		1		1								
Forcipomyiinae		1		1								
Hemerodromia	4			4	2	1		3				
Hexatoma					1	1		2				
Nemotelus									1			1
Ormosia									1			1
Prosimulium									2			2
Simulium	7		3	10	56	1	1	58	30		4	34
Stratiomys									1	1		2
Tabanus						*						
Tipula	2			2	1	*	1	2		1		1
Lepidoptera												
Petrophila												
Pyralidae		*										
Total Individuals	594	330	332	1256	574	260	287	1121	579	335	232	1146
Taxa Richness	51	57	51	96	51	56	45	86	61	59	47	100

Appendix C

Sediment Lead and Zinc Character
September 2001

Appendix C

Sediment lead and zinc character per station and grids. Probable Effects levels (PEL, Ingersoll et al. 1996).

Sample Numbers 01-39386 through 01-39372 from upstream to downstream. Units ug/kg Total Recoverable.

Station		Lead		Station Average		Zinc		Station Average
	Grid 1	Grid 2	Grid 3	PEL-Lead 82,000	Grid 1	Grid 2	Grid 3	PEL-Zinc 540,000
Big River #3	15,400	17,300	16,000	16,233	51,200	24,400	25,000	33,533
Big River #2	18,200	18,900	16,900	18,000	25,500	40,900	35,500	33,966
Big River #1	21,000	14,300	29,400	21,566	34,900	44,800	59,500	46,400

Appendix D

Comparisons: Fine Sediment, Lead, and Zinc:
Kruskal-Wallis One Way Analysis of Variance on Rank,
Tukey Test and Dunn's Method, All Pairwise Multiple Comparison Procedures
(All data set and with Cedar Creek grid removed)
September 2001

Kruskal-Wallis One Way Analysis of Variance on Ranks Thursday, March 13, 2003, 13:09:11

Data source: Big River: Fine Sediment Comparison, Grouped by Stations (All Data)

Normality Test: Failed (P = <0.001)

Group	N	Missing	Median	25%	75%
1.000	18	0	0.205	0.0700	0.500
2.000	18	0	0.0350	0.0200	0.0700
3.000	18	0	0.0450	0.0200	0.120

H = 13.879 with 2 degrees of freedom. (P = <0.001)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparison	Diff of Ranks	q	P<0.05
1 vs 2	324.500	4.862	Yes
1 vs 3	277.000	4.150	Yes
3 vs 2	47.500	0.712	No

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Kruskal-Wallis One Way Analysis of Variance on Ranks Thursday, March 13, 2003, 13:02:31

Data source: Big River: Lead Comparison, Grouped by Stations (All Data)

Normality Test: Passed (P = 0.024)

Equal Variance Test: Failed (P = 0.006)

Group	N	Missing	Median	25%	75%
1.000	3	0	21000.000	15975.000	27300.000
2.000	3	0	18200.000	17225.000	18725.000
3.000	3	0	16000.000	15550.000	16975.000

H = 1.689 with 2 degrees of freedom. P(est.)= 0.430 P(exact)= 0.511

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.511)

Kruskal-Wallis One Way Analysis of Variance on Ranks Thursday, March 13, 2003, 13:07:04

Data source: Big River: Zinc Comparison, Grouped by Stations (All Data)

Normality Test: Passed (P > 0.200)

Equal Variance Test: Passed (P = 0.861)

Group	N	Missing	Median	25%	75%
1.000	3	0	44800.000	37375.000	55825.000
2.000	3	0	35500.000	28000.000	39550.000
3.000	3	0	25000.000	24550.000	44650.000

H = 1.867 with 2 degrees of freedom. P(est.)= 0.393 P(exact)= 0.439

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.439)

Kruskal-Wallis One Way Analysis of Variance on Ranks Thursday, March 13, 2003, 13:11:04

Data source: Big River: Fine Sediment Comparison, Grouped by Stations w/o Cedar Creek

Normality Test: Failed (P = <0.001)

Group	N	Missing	Median	25%	75%
1.000	18	6	0.160	0.0700	0.280
2.000	18	0	0.0350	0.0200	0.0700
3.000	18	0	0.0450	0.0200	0.120

H = 7.663 with 2 degrees of freedom. (P = 0.022)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.022)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Dunn's Method):

Comparison	Diff of Ranks	Q	P<0.05
1 vs 2	13.875	2.659	Yes
1 vs 3	11.347	2.175	No
3 vs 2	2.528	0.542	No

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Kruskal-Wallis One Way Analysis of Variance on Ranks   Thursday, March 13, 2003, 13:15:02

Data source: Big River: Lead Comparison, Grouped by Stations w/o Cedar Creek

Normality Test: Passed (P > 0.200)

Equal Variance Test: Passed (P = 0.012)

Group	N	Missing	Median	25%	75%
1.000	3	1	17650.000	14300.000	21000.000
2.000	3	0	18200.000	17225.000	18725.000
3.000	3	0	16000.000	15550.000	16975.000

H = 1.361 with 2 degrees of freedom. P(est.)= 0.506 P(exact)= 0.564

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference   (P = 0.564)

Kruskal-Wallis One Way Analysis of Variance on Ranks Thursday, March 13, 2003, 13:17:33

Data source: Big River: Zinc Comparison, Grouped by Stations w/o Cedar Creek.

Normality Test: Passed ($P > 0.200$)

Equal Variance Test: Passed ($P = 0.742$)

Group	N	Missing	Median	25%	75%
1.000	3	1	39850.000	34900.000	44800.000
2.000	3	0	35500.000	28000.000	39550.000
3.000	3	0	25000.000	24550.000	44650.000

$H = 0.694$ with 2 degrees of freedom. P(est.)= 0.707 P(exact)= 0.757

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference ($P = 0.757$)